Spacecraft Internal Acoustic Environment Modeling

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Background

The acoustic noise environment has been identified by the Astronaut Office, Habitability and Environmental Factors Division, and the SHFE Gap Analysis as one of the top habitability concerns, and a key area for improvement, regarding Constellation spaceflight vehicles, including the Crew Exploration Vehicle, Lunar Surface Access Module, Lunar Habitat, and Mars vehicles. The “Acoustic Modeling” directed research project has been established to provide vehicle acoustic environment models and institutional capability to assist the Constellation Program with design and oversight tools aimed at avoiding acoustics-related problems.

Risk of Reduced Safety and Efficiency Due to Poor Human Factors Design

A high-noise environment may increase the risk to safety, health and productivity of the crew due to fatigue, reduced communication effectiveness, and increased risk of temporary and permanent hearing loss. The aim of this project is to develop acoustic modeling as a tool to design and develop quieter space vehicles, and will reduce this risk.

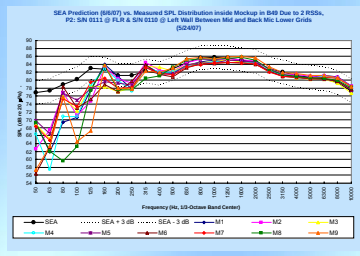
Objective

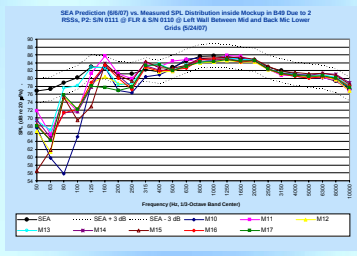
The objective of the project is to develop an acoustic modeling capability, based on commercial off-the-shelf software, to be used as a tool for oversight of the future manned Constellation vehicles. The use of such a model will ensure compliance with acoustic requirements, provide a safe and habitable acoustic environment for the crews, and to validate developed model via building physical mockups and conducting acoustic measurements.

Products/Deliverables

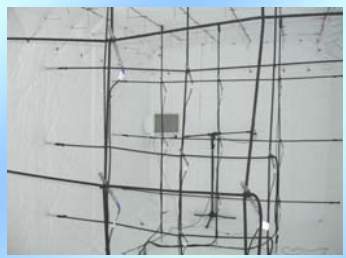
- Developed SEA (Statistical Energy Analysis) model representing airborne noise sources with known sound power levels.
  - Simple rectangular room geometry
  - Single and multiple sources
  - Various reverberant conditions: hard wall, wall fully covered by one (1) and two (2) layers of Thinsulate material
  - Two methods to model absorption: reverberation time → Sabine Equation, and impedance tube tests → identification of five (5) material properties via curve fitting → single or multi-layered lay-up model
- A rectangular shaped plywood/MDF mockup was built and used for validating the prediction of the model in SPL (Sound Pressure Level) prediction via seventeen (17)-microphone measurements. The modeling results were evaluated based on the accuracy of sound pressure levels over a wide frequency range, and the frequency range where SEA gives good results were observed.
- Both single-cavity and subdivided-cavity models were built. The later is better suited for highly absorptive environment.
- Future Products/Deliverables will include:
  - CEV CM mockup located in the Acoustics and Noise Control Laboratory (ANCL). In FY07 the CEV frame was assembled. The mockup is to be completed during FY08 with modification reflecting the design changes of the interior habitable volume.
  - Model to predict Acoustic Transmission Loss of the mockup wall and ECLSS wall.
  - Acoustic model with the Orion CEV interior shape with noise predictions based on input noise sources. These predictions will be verified with the use of a physical mockup that will imitate the actual Orion vehicle to the greatest extent possible based on budget limitations. The development of an acoustic model of the actual Orion vehicle will be used to assist Orion design reviews for sub-allocations and overall predicted levels.

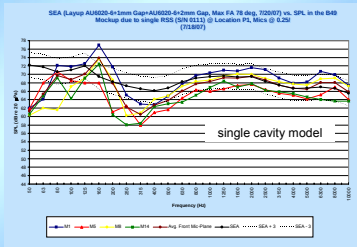
Rectangular Mockup at JSC B49, Hard Wall

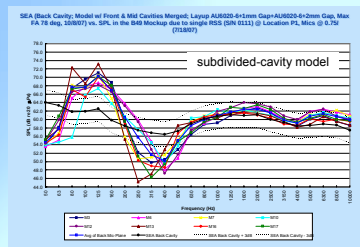




Rectangular Mockup at JSC B49, Absorptive Wall







Virtual Acoustic Transmission Loss Test